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CENTRAL INTELLIGENCE AGENCY
INFORMATION FROM
FOREIGN DOCUMENTS OR RADIO BROADCASTS

REPORT
CD NO.

50X1-HUM

COUNTRY	USSR	DATE OF INFORMATION	1948
SUBJECT	Scientific - Engineering, metallurgy		
HOW PUBLISHED	Monthly periodical	DATE DIST.	30 Nov 1950
WHERE PUBLISHED	Moscow	NO. OF PAGES	6
DATE PUBLISHED	Sep 1948		
LANGUAGE	Russian	SUPPLEMENT TO REPORT NO.	

THIS IS UNEVALUATED INFORMATION

SOURCE Vestnik Mashinostroyeniya, Vol XXVIII, No 9, 1948, pp 33-38,

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NEW ASPECTS IN MAKING CASTINGS OF MODIFIED CAST IRON IN THE USSR

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Production of high-grade modified cast iron is still below the level established by special government decree in 1944.

Only a few plants make castings of modified cast iron, chiefly of the first two grades under GOST 2611-44, i.e., those with a tensile strength of 32 kg/sq mm. Systematic production of castings with a tensile strength of 35 kg/sq mm is proceeding only in individual plants. No castings are made of the highest grade of cast iron with a tensile strength of 38 kg/sq mm.

Uralmashzavod (Ural Machine Building Plant) conducted experimental production of castings using all the types of modified cast iron established by GOST 2611-44. The satisfactory experiment of Uralmashzavod is based on results of special investigations which permitted development of a unique, effective, technological process of modification.

Production of castings made of modified cast iron is continuously increasing at the Uralmashzavod and in February of 1948 reached 15% of total production.

Table 1 gives the chemical composition of three grades of cast iron which were established preliminary to production melting.

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Table 1. Grades of Modified Cast Iron and Their Application

Application of Cast Iron	Chemical Composition (%) C	Si Before Modification	Si After Modification	Mn	P	S	Cr	Ni
For particularly intricate castings with abrupt changes in section with minimum thickness of 8 mm	3.1-3.4	1.4-1.7	1.6-1.9	0.8-1.2	0.35 max	0.12	0.10-0.25	0.35 max
For intricate castings with various thickness of walls and minimum thickness of 15 mm	2.9-3.3	1.1-1.4	1.3-1.6	1.9-1.3	0.30 "	0.12	0.15-0.30	0.50 "
For ordinary castings with cross-section thickness over 20 mm	2.8-3.2	0.8-1.2	1.1-1.5	1.0-1.3	0.30 "	0.12	0.20	0.70 "

Application of Cast Iron	Steel Content in Furnace Charge (%)	Brinell Hardness No	Grade of Cast Iron Acc to GOST 2611-44
For particularly intricate castings with abrupt changes in section with minimum thickness of 8 mm	40	170-241	MS4-28-48
For intricate castings with various thickness of walls and minimum thickness of 15 mm	60	197-248	MS4-32-52
For ordinary castings with cross-section thickness over 20 mm	70	197-262	MS4-35-56

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Introduction of alloying elements (Cr and Ni) in small amounts sharply improves mechanical properties and secures stability.

Data on the investigation of production melts for a 14-month period were analyzed statistically. All melts, with respect to mechanical properties, were divided into two groups: one group of cast iron with a bending strength from 48 to 52 kg/sq mm, and a second group with bending strength over 56 kg/sq mm.

Study of the results obtained showed that cast iron of the second group with higher mechanical properties has a lower carbon content as compared with the first group. Both groups are very near to each other in regard to manganese content.

The content of alloying elements is a basic difference in the chemical composition of these two groups.

For better clarification of the significance of alloying in modified cast iron, a special curve was constructed, as follows: the alloying coefficient $K = \frac{Cr + Ni + Mn + Mo}{Si \quad C}$ was plotted along the abscissa, where Cr, Ni, Mn, and others are percentages of these elements; the values of bending strength were used as ordinates. A graph of this kind permits selection of the proper composition of cast iron to satisfy prescribed properties.

The following conclusions may be drawn:

1. Mechanical properties of modified cast iron have a definite relation with the coefficient K: they are improved (in the investigated range) with the increase of the K value.

2. Microstructure of the cast iron does not reveal any noticeable difference in the shape and distribution of graphite in spite of variations in values of K and related changes in mechanical properties. However, the cast iron with higher K has smaller grains in fracture and greater dispersion of the base metal structure. Thus, improvement in mechanical properties with higher degree of alloying may be explained by the lower grain size and general increase in strength of the basic metal mass.

These two factors have decisive significance in the improvement of mechanical properties; the decrease of carbon content is much less essential. This latter conclusion is of great practical importance, since a sharp decrease in the carbon content is not required in many cases. Such a decrease usually leads to low castability.

It is known that melting of modified cast iron requires strict adherence to the prescribed chemical composition. For establishing the required percentage of steel in a charge for various grades of cast iron, the authors used an ordinary steel charge, with some pieces weighing as much as 50-100 kg. Results of these melts did not reveal any direct dependence of the carbon content on percentage of steel in a charge. This dependence also was not detected with respect to the mechanical properties. Such a failure may be explained by uneven and slow melting due to large chunks of steel and the low temperature of the metal (1,380° average).

The second series of experiments was carried out to investigate the quality of cast iron when using for the furnace charge very small steel chips with a thickness from 2 to 8 mm and weighing from 100 to 600 g per piece.

Results of some melts are given in Table 2. The first three melts were made in the laboratory and the others were usual production melts. Utilization of small steel chips did not increase the amount of slag and did not show any noticeable increase of oxides in the slag. Simultaneously, a sharp rise of temperature to 1,420-1,440° was revealed, a factor not observed before.

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Table 2. Mechanical Properties of Cast Iron Made Using Small Steel Chips

	Chemical Composition (%)								Mechanical Properties				
No of Melts	C	Si	Mn	P	S	Cr	Ni	Mo	Bending Strength (kg/sq mm)	Deflection (mm)	Diam Reduction /unit not given/	Tensile Strength (kg/sq mm)	Steel % in Furnace Chg
12.6	2.60	2.19	0.81	0.11	0.053	0.52	0.77	0.23	102.3	5.0	3.60	42.4	80
12.7	2.70	2.62	0.70	0.13	0.062	0.50	0.50	0.10	62.0	4.0	3.75	39.5	70
12.8	2.65	2.00	0.62	0.17	0.080	0.50	0.50	--	66.0	4.5	3.60	31.7	60
37.0	3.20	1.18	0.93	0.22	0.088	0.06	0.38	--	62.3	4.5	3.70	--	50
58.0	3.15	1.34	0.92	0.16	0.072	0.06	0.48	--	69.0	5.0	3.80	--	50
59.0	3.10	1.90	1.03	0.17	0.080	0.19	0.42	--	59.4	4.0	3.80	--	50
72.0	3.10	1.50	0.76	0.16	0.090	0.10	0.36	--	65.3	4.5	4.20	--	50
73.0	3.35	1.54	1.19	0.18	0.093	0.11	0.35	--	70.0	4.5	3.70	--	50

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Melting proceeded smoothly and variations in chemical composition were insignificant. A decrease in the carbon content to 2.6-2.7% was achieved in laboratory melts conducted in a cupola furnace with a capacity of 750 kg/hr. The low content of carbon and increased content of alloying elements, attained by utilization of steel chips, made it possible to obtain cast iron with very high mechanical properties.

Thus, the experiments described here disproved the existing opinion that a charge of small steel chips has increased tendency to carburization. Obviously, the carburization degree depends mainly on the rate of melting: the more forced the melting process, the lower the content of carbon in the cast iron with the same percentage of steel in the charge.

The following assumption also may be accepted: The fine steel component of the charge, having an increased ratio between surface and volume, maintains more intensive oxidation up to the moment of melting. Oxides may hamper the carburization process, since a certain amount of carbon would be used for reduction of iron from the oxides.

As a result of the experiments, the Uralmashzavod adopted systematic utilization of steel chips, which were never before used for producing cast iron.

The experiments also proved the possibility of using small steel scrap and sprues of steel castings.

Melting was conducted in ordinary cupola furnaces without any modification of blowers. A certain deficiency in air is permissible (80-100 cu m instead of the 125-140 cu m per sq m per min as suggested by the Central Scientific Research Institute of Machine Building).

Production of large castings involved certain difficulties, mainly because of low production capacity of the cupola furnaces. The necessary amount of metal was accumulated slowly, and considerable cooling of metal in ladles took place. However, the process of modifying cast iron for large castings was experimented on and introduced into production. The method of modification in pouring basins, developed by the Kramatorsk Plant, proved to be satisfactory. To attain a sufficiently high temperature of the metal at the time of modification, a certain portion of the cast iron, about 10-20%, was melted in the electric furnace with considerable overheating, and added to ladles with metal taken from cupola furnaces. Table 3 gives the chemical composition and mechanical properties of several large castings made by this method.

Table 3

Grade of Cast Iron	Wt of Casting	Chemical Composition: C	Si	Mn	P	S	Cr	Ni	Mechanical Properties: Bending Strength (kg/sq mm)	Deflection (mm)	Diam Reduction /unit not given/
MS4	54	3.10	1.05	1.02	1.12	0.066	0.06	0.29	53.7	4.0	4.2
MS4/32-52	35	3.30	1.58	1.00	0.15	0.042	0.09	0.37	4.0	5.5	4.4
MS4-28-48	34	3.25	1.76	0.81	0.17	0.048	0.06	0.37	42.5	4.0	4.2
MS4-28-48	54	3.05	1.32	0.91	0.14	0.044	0.08	0.42	51.0	5.0	4.2

Final conclusions are as follows:

1. Utilization of naturally alloyed pig iron is recommended for introduction of small additions of chromium and nickel into the composition of modified cast iron. The higher the expected quality of the cast iron the greater must be the addition of alloying elements.

2. The considerable decrease in carbon content is not imperative in cases of application of alloying.

3. Coarse stripping chips and sprues from steel castings must be used as a steel component of the furnace charge. The higher the ratio of the surface of steel chunks to their volume, the smoother and more forced is the melting process and the higher is the temperature of the metal at tapping.

4. The usual concept that fine steel scrap used in the charge increases carburization, is not substantiated.

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